January 26—"Lewis and Clark Expedition to the Head of the Columbia," Warren K. Moorehead.

February 9—"Lewis and Clark Expedition to the Pacific," Warren K. Moorehead.

February 23—"Caves at Home and Abroad," Charles Peabody.

March 9—"Social Life of the American Indians," Warren K. Moorehead.

March 23—"Lake Dwellings and the Bronze and Iron Cultures," Charles Peabody.

April 13—"Origin, Accomplishments and Destiny of the American Indians," Warren K. Moorehead.

UNIVERSITY AND EDUCATIONAL NEWS

At the annual Michigan Union banquet at the University of Michigan Mr. Clarence W. Barbour, representing the Michigan alumni in New York, announced that plans had been perfected and funds subscribed for the erection of a $300,000 dormitory, with a large "commons."

The H. K. Cushing Laboratory of Experimental Medicine at Western Reserve University was dedicated on the afternoon of November 20, when Dr. H. W. Welch, of the Johns Hopkins Medical School, made the principal address. The building, complete in all its appointments, is of reinforced concrete, faced with brick. It is 55 × 40 feet, and consists of four floors. On the first floor is a large room for chemical work, and in connection with this is a balance room, the balances being arranged on a solid concrete pier. A workshop, a store room, a dark room for photographic purposes, and for the reception of a centrifugal, complete the accommodation on the first floor. On the second floor is the library, and one large and several small rooms for individual investigations. Also, a refrigerator room, a room for maintaining a constant temperature and a chemical store room. The third floor has several rooms for students, and the fourth rooms for the study of nutrition in animals under the influence of different diets, with a view to throwing light on the diseases of nutrition in man. The building is practically fireproof. The laboratory is named for Dr. H. K. Cushing, who was for many years associated with the Cleveland Medical College, which later became the medical department of Western Reserve University. Dr. George N. Stewart is professor of experimental medicine and director of the laboratory.

The Rev. Dr. W. A. Shanklin, president of Upper Iowa University, has been elected president of Wesleyan University.

Dr. Frederic E. Farrington, who spent last year in France, studying especially the secondary schools of that country, goes this year from the University of California to the department of education in the University of Texas. In the latter institution he occupies the newly-established chair of associate professor of education in charge of the observation and practise of teaching.

Dr. Stanley R. Benedict, formerly assistant in physiological chemistry at Yale University, has been appointed instructor at Syracuse University.

Howard Lane Blackwell, Ph.D., has been appointed fellow for research in physics at Harvard University.

DISCUSSION AND CORRESPONDENCE

SIDE ISSUES BEARING ON THE AGE OF NIAGARA FALLS

In a late issue of Science (July 31, 1908), a notice of my recent book upon Niagara Falls was published by Dr. G. K. Gilbert,[1] which is chiefly a discussion of three minor problems, the treatment of which could scarcely be considered a necessary digression from the main issue of my book. In his dealing with these, a doubt is left as to the correctness of my conclusions regarding the age of Niagara Falls; and a substitution is given in his own behalf, announcing, without the evidence, that their duration is more than four times that of my computation, which computation was based upon the most carefully measured details of the work accomplished during each stage of the physical changes of the river. This correspondence is cordially welcomed in that it renews the interest in the subject, for as Professor James Geikie has

[1] "Evolution of the Falls of Niagara," by J. W. Spencer, pp. i–xxxi, 1–490, Geological Survey of Canada, 1907.

somewhere said—when controversy ceases the interest passes away, and the truth generally lies between the extremes. The value of the points raised must be taken in their magnitude relative to what has already been established in the investigations of Niagara Falls; accordingly, a backward sketch of some of the results must be made.

Years ago Dr. Gilbert presented data, in mathematical form, demonstrating that the Falls were no more than 7,000 years old, with several modifications tending to lower even this estimate (page 372). Shortly afterwards, my discovery that the Huron discharge had formerly nothing whatever to do with Lake Erie, or the Niagara (page 294, also Chap. XXV., and Ap. VII.), changed the then new idea of the short age of Niagara Falls. This now universally accepted fact is further proved by new soundings (pp. 71, 73), within and without the end of the gorge, bringing to light a narrow deep inner channel that could carry only the Erie drainage. The same phenomena I also found in the expanded reaches of the St. Lawrence River (Chap. XXIX.). Furthermore, the drowned channels among the swamps of Lake St. Clair furnished additional proof of the original northward discharge of the Huron waters (Chap. XXVI.).

From the structure of the terraces at Foster's Flats (Chap. XIV.), and the excavated depth of the channel above them (p. 66), I have been able to establish the location of the falls when the discharge of the Upper Lakes was added to the early Niagara River. In soundings and borings, the nature of the gorge at the Whirlpool Rapids has at last been revealed (Chap. V. and XII.). My soundings under the falls, the only ones that have ever been made (p. 56) have brought to light the reduced depth of the basin beneath (p. 48). This was exceedingly important, as it revealed the recent damming of the channel, which raised the level of the river in the basin just below the great cataract, thereby shortening the otherwise calculated age of Niagara Falls, while they were receding the last three miles, by thirty per cent.

The ancient volume of the river has been computed on a sound basis at fifteen per cent. of the full discharge of the four Upper Lakes, an amount closely agreeing with that previously calculated for the Erie drainage by Mr. Thomas Russel (U. S. Lake Survey), his result being 16.7 per cent. (p. 252). These and other features, such as the origin of the Upper Rapids (p. 166 *et al.*), dependent upon preglacial phenomena, cover some of the most important changes in the complex history of the cataract, all of which show that the energy of the falls has increased tenfold, or 1,000 per cent. This increased power is not questioned, but established.

Per contra, my critic raises three points, the relative importance of which will be seen upon the examination of each. One of these is the relative "efficiency," or, in other words, what has been the loss of work during the changing energy of the cataract. He says: "To say that the rate of recession is proportional to the energy is equivalent to saying that the efficiency does not change with the variation of energy," but in my statement I added "provided other conditions remained constant" (p. 350), and my whole book is a differentiation and measurement of the changing conditions. To the paragraph, just quoted from the review, my attention was called by a layman. His omission of the word "relative" before efficiency left on the layman's mind an impression that the critic fallaciously supposed that I had made a fundamental error. As the word efficiency is repeated a score of times, the science of the falls demands investigation of the point raised. He urges a comparison of the relative efficiency of the changing energy of the falls with a man-made engine, and says that "the computed energy of the American Falls does not differ greatly from the computed energy of the main cataract during the longest division of its history." Let me say that the now measured discharge shows that during the earlier period the volume of the main cataract was three times that of the American Falls of recent origin.

If we are to seek analogies, let it be noted that the kind of man-made engine most nearly approaching a waterfall is a water-wheel or turbine, though it is not so stated. Rankine,

whom he quotes, mentions that in numerous trials the efficiency of different wheels varied from 66 to 80 per cent. The loss actually questioned is the difference between these figures, which shows that the relative work performed by the worst machine is only 17.5 per cent. below that of the best. In the turbine wheel there is a loss from leakage as well as from friction, which does not occur in the natural falls, where, however, there is wind effect. As the American Falls represent 200,000 gross horse-power, which is very much greater than any turbine, the relative loss of power should be very small compared with even the best engine. In testing the relative loss of power in turbines, Kent[2] mentions that in diminishing the supply of water to half the flow, in one kind of turbine, the useful work fell six per cent. only. This is the best kind of illustration for comparing the efficiency of the changing volume of the cataract with a man-made engine. The loss of work to the extent of six per cent. in the American Falls over that of the Canadian, due to smaller volume, would cause only an increase in the computed age of Niagara Falls of less than 2,000 years (or a difference in efficiency of ten per cent., would add less than 4,000 years) in excess of the 39,000 years. This only possible increase, if not counteracted by other minor elements, is provided for in the anticipated variation of ten per cent. (p. 369). The smallness of the variation suggested is better appreciated when it is compared with the discoveries of increased energy (1,000 per cent.), which has raised the supposed age of the falls from less than 7,000 years (Gilbert, formerly) to 39,000 years (Spencer).

However, if any allowance should be made, as above set forth, there is another physical component of about equal importance, the effect of which would counterbalance any relatively inferior efficiency of the smaller falls. Both are small factors compared with the great changes of energy discovered.

The second point raised is a plea for measuring the age of the whole gorge on a basis of the recession of the American Falls. He says: "The American Fall does not differ greatly from the computed energy of the main cataract during the longest division of its history," and further states that if I had used these falls for the basis of my calculations (or a formerly provisional rate based upon incomplete data obtained from measurements made in 1868, since abandoned for complete ones), the age would have been nearer 20,000 than 39,000 years, but I may say that with the full treatment of the subject, from even the partial data published, any one would have found the computation to have reached 32,000 years. But no computations based on the American Falls were attempted by me. He also says with regard to the recession of the American Falls: "It may with confidence be said that 0.06 foot a year [in recession] is nearer the truth than 0.60, but no definite estimate is warranted." This latitude in comparison reaches 0.32 foot (thirty-two hundredths), which appears to be what he meant, because in his official bulletin,[3] page 22, he gives this figure as one of his conjectures, but in the controversy one would think that he meant little more than the lesser amount (0.06). Using his coefficient of 0.32 foot, the age of Niagara would be over 37,000 years (not 20,000 years).

In my Niagara book, I stated that the American Falls had receeded 0.60 foot between 1842 and 1890, which was true for that period. More recent surveys show that afterwards, down to 1906, no further important changes had occurred. Thus the measured rate is reduced to 0.47 foot a year. This must be further diminished to 0.35 foot in comparing the work with that of the Canadian Falls. The mean total longitudinal recession has been only 29 feet since the first measurements were made, while that of the greater cataract has been 265 feet, and the discharge measurements show that it carries 95 per cent. of the volume of the whole river.

The recession is intermittent; in the one case the amount is so small that we do not know whether the cycle has been completed during the period of observation or not. Here a small error from any cause would prevent

[2] Kent's "Engineering Pocket Book," p. 596.

[3] Bulletin U. S. Geological Survey, No. 306, 1907.

the estimated rate being of more than approximate value. In the case of the main cataract, there have been many cycles, so that an error in one is not fatal to the determination of a mean rate.

In his recent report upon the recession of Niagara Falls,[4] Dr. Gilbert devotes much space in trying to prove as erroneous Professor Hall's survey (1842), which shows a shelf since fallen away. Without discrediting Hall's work, it seems much more probable that a cycle of undercutting had commenced prior to his survey, though the floor of the river fell afterwards, so that his measured amount of recession belongs to a longer period. The protruding shelf shown by Hall is also indicated on the map of the International Boundary Survey of 1819. On this basis the mean rate would be reduced to 0.34 foot (or for comparative purposes to 0.26). It we were to estimate the rate of recession of the smaller cataract in terms of the greater, it would be 0.28 foot a year (or for comparison, 0.22 foot). On the basis of 0.34 foot, the age of the Falls of Niagara would be found to be 37,000 years, which nearly approaches that already stated in my book. If 0.28 be taken, the result would of course be the same as that based on the main cataract. Conclusive measurement could not be made during a lifetime, besides which the spoliation of the cataract for power purposes will destroy the natural conditions; yet additional data are obtainable, so that it will be possible to write a supplementary chapter on the recession of the American Falls, now that the collateral evidence is called for.

There are other factors in the physics of the falls of differential value, but they are all embraced in the actual work done by the two cataracts, the relative efficiencies of which do not greatly differ, as shown above, upon the problem being analyzed scientifically. This opportunity of confirming my previous calculations affords me great satisfaction.

As to the recession surveys of Niagara Falls, it may be stated that mine of 1904 was the fifth one of the main cataract ever made (Preliminary Report of the Geological Survey of Canada for 1905, published in the summer of 1906), preceding by a few months that of Mr. W. Carvell Hall. In using this last-mentioned survey, Gilbert computes his rate of recession from only that portion of the falls where the greatest depth of water occurs, although that portion is some hundreds of feet less than the diameter of the cataract which has been making the gorge of an equal width. In his calculation, he also uses the mean of ordinates unequally placed. Thus he gives a result of 5.3 feet a year, but on page 25 he adds that there is an uncertainty of one foot. This estimate of five feet a year affords no coefficient of recession throughout the gorge. If corrected for the full width, the rate would be found to approximate that of mine. He also says that the recession between 1875 and 1905 was greater than in the previous thirty-three years; but had he broken up the former period into two divisions of fifteen years each, he would have found a great reduction in the rate of recession during the latter fifteen years. In his application of the rate of five feet in determining the recession of the American Falls the result would give too short a time, had there not been a previous acceleration, due to the higher stage of the cataract during its earlier history (unknown until discovered by my soundings under the falls). These compensating omissions, however, give an approximately acceptable rate (0.32 foot).

Thirdly, my critic says:

> If the efficiency of Niagara in producing recession varies according to the law, as the efficiency of a river in transportation, Spencer's estimate of the age of the river should be multiplied by a factor larger than four.

Lake Erie is a settling basin, so that only after occasional severe storms does the lake send down its turbid waters into Niagara River, and then only for a short time, but this small quantity of detritus, even then, varies with the volume and velocity of the river and is lost in the general averages of the discharge measurements. The volume of detritus removed from the channel of the river since its birth is less than a thousandth part of the volume of water that flows down each year. Again, it requires 900 tons of water to loosen every pound of rock carried

[4] Bulletin cited before.

away from the gorge in the recession of the falls, which is occasioned by the undercutting in the soft strata, and not by the abrasion from an infinitesimal quantity of detritus. The capacity of streams for transportation varies as the sixth power of the velocity, while the erosion varies only as the square of the velocity. I do not understand the ground for comparing the clear-water Niagara with the experiments based upon transportation of muddy water of other streams. But we can get an inkling as to the relative abrasion at Niagara. Only since the falls have receded the last mile and a half have the Upper Rapids come into existence (1,500 years ago or less). In the meanwhile the river, with its dissolving waters, ice, detritus and currents, has not made any true channel next to the head of Goat Island, while at the foot, after the rapids have descended over fifty feet, all of these forces together have only cut in the rock to a depth of four feet—and this while the falls have been receding a mile and a half. If the recession were proportional to the detritus, which he assumes as ground for quadrupling my computations, we should certainly have to raise his conjectural age into millions of years. The proposition of measuring the work of Niagara Falls by transportation of detritus is certainly irrelevant.

Concerning the soundings, it is further stated that my apparatus was of the Kelvin type. This statement requires correction. That used by me was invented and patented by Lieutenant Blish and Commander Tanner, officers of the U. S. Navy. It is entirely a different and better device for recording the depths than that of Kelvin, whose instrument could not have been used in fresh water. Commander Tanner kindly lent me some of the apparatus.

Dr. Gilbert says:

> But while the discovery of the real law of efficiency would be a notable contribution to the problem, it would not remove every difficulty. In its proper application there would be need to take account of various qualifying conditions, not all of which are easily evaluated.

He then specifically mentions five. Here indeed I not only accept his conditions, but I did anticipate them, giving the most detailed measurements of them, with many sections drawn to scale, and other illustrations. These I shall take up consecutively.

(1) "Width of gorge as affecting quantity of erosion," and I may add depth. These subjects are fully discussed, with numerous sections determined instrumentally, in chapters V. to X. and parts of XII. and XIV. (2) "Depth of the gorge from the crest of falls to bottom of pool." This has been measured for the first time, by me, and described in a headed page (56), figured section (p. 48), further explained (p. 86), and applied in calculations (p. 367). (3) "Concentration of flow as affecting efficiency." This is discussed, in relation to points raised, in chapters IX., XII. and XIV. (and p. 368). (4) "Thickness of the capping limestones as affecting efficiency." This is shown in tabular form at many points (p. 90), in many figured sections (Chap. VIII. and pp. 50, 343), and in other references and with a time allowance (p. 369). (5) "The relation of the Medina sandrock to efficiency." A table is shown to illustrate this (p. 90), also many figured cross-sections (Chap. VIII.) and longitudinal ones (pp. 50 and 343). These show that the Medina sandrock had no relationship whatever to the uppermost cataract upon which was based the recession during the first 35,000 years, and in the last 3,500 years, to only an infinitesimal amount. These features may be redescribed by others, but any student will find all of them described in my book as nowhere else, many for the first time, which will furnish him with data for working out specific problems that I may have deemed immaterial. Finally he says that "Spencer's computations do not include data bearing upon these variables." I am surprised that any one should have read my book and failed to take account of the distinct and articulate chapters, headed paragraphs and illustrations, covering all of these points. He also mentions my discussion of the present stability "of the land in the Great Lakes region, with the conclusion that no earth movements have occurred in modern times," without further comment, as

if concurring with me, when here I should have expected dissent, as the results are at variance with his former opinion.

In my book upon the Falls of Niagara, I have set forth the data found in my researches, by which their changing history has been discovered. The age of the falls is a very interesting, though secondary, problem. My observations may be repeated by others, with variations in treatment. The leading points raised by Gilbert are variations in treatment, of magnitude relatively small; and a third (that upon which he indicates his belief in their great antiquity) rests upon inadmissible analogies. All of these points, though tending to divert attention from the main issues, in reality confirm my conclusions. I have no theory as to the length of time to defend, except that which is suggested by the changing physical conditions, as measured by the falls, in the gorge and in the volume and height of the cataract, and as I have said in my book, a matter of a few thousand years does not make an important variation in the value of my pioneering work "in the correct line of investigating the problems presented by this remarkable region." I am pleased that my critic thinks that the determination of the age of Niagara lies within the scope of observation, and is of so much popular and scientific interest.

J. W. SPENCER

WASHINGTON, D. C.,
November 1, 1908.

THE QUESTION OF PROFESSORS' SALARIES

THE statement is sometimes made, that a general increase in the salaries of college and university professors would be of no service to the institutions concerned, in improving the character of the men available for professorships. I believe this view to be incorrect, especially as concerns our colleges; and I venture to present the following suggestions for the consideration of those who hold it.

A general survey of the institutions of learning, large and small, throughout the land, leads to the painful conclusion that our faculties no longer, as they once did, represent groups of cultivated men. The word "culture" has of course fallen into disrepute in our day; but the cultivated man, while we no longer aim to produce him, demands and receives our respect and admiration wherever he is found. It would not be difficult to cite a few notable survivals of the type here and there. The rarity of teachers of this kind in our college and university faculties to-day will be readily admitted by all who have any intimate knowledge of the matter. Yet the desirability of having such men as instructors of undergraduate students is keenly felt by those who have to choose a college for their sons. The function of the undergraduate course is precisely to give the student what he will not get when as a graduate he enters the special field of his life work; therefore the undergraduate course should give the student a general enrichment of life; which is exactly what we mean by cultivation.

But we are content at present that the highest product of our educational system should be the specialist; a man usually thoroughly conversant with one small branch of learning, and fairly well acquainted with some allied subjects, but often ignorant in every other field of human interest, without ideas of his own in any field but his own, and dead to everything that can be classed as the amenities of life—the arts, literature, human society.

I venture to suggest that our specialist is a man of this kind because he comes from a home which lacks those things of which we now deplore the absence in him. Then why do our institutions of learning draw from such a class of material? They have no choice; and for this reason: the youth who decides on the teaching profession as his career must of necessity abandon the idea of accumulating money; that surely no one will dispute; and there are many who are willing to accept this as a condition of their existence. But very few are willing to abandon the ambition for wealth as an aim in the future, and at the same time to accept a present and permanent reduction in their scale of living. For the ambition not to be rich makes for happiness about as well as the ambition to be rich; but it does not make for happiness to